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University Collaborations for Safeguards/Nonproliferation Education
A Next Generation Safeguards Initiative Workshop Report

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University Collaborations for Safeguards/Nonproliferation Education Workshop
Inn at Loretto, Santa Fe, NM
August 10-13, 2009

Introduction

During the week of August 10-13, 2009 Los Alamos National Laboratory (LANL) and Texas A&M University (TAMU) held a workshop on Nuclear Safeguards/Nonproliferation Education in Santa Fe, New Mexico. The workshop was intended to inform university faculty nationwide regarding NNSA and national laboratory programs to strengthen nuclear safeguards education. In turn, it sought to gather academic perspectives on making these activities as effective as possible. The workshop also focused on the development of course materials and assessed various learning tools for this vital area of study. Multimedia information-sharing tools and distance learning capabilities were discussed as well as specific ways that national laboratory staff and university faculty can collaborate in order to expand and energize nuclear safeguards and nonproliferation education across the country. Also highlighted was the continuing need for developing a better understanding of workforce need in order to shape educational efforts to meet that need.

Seventeen faculty members from 16 different Universities participated in the workshop along with nearly a dozen laboratory experts and representatives from the National Nuclear Security Administration (NNSA).[1] The workshop is an activity of the Next Generation Safeguards Initiative (NGSI) human capital development project, supported and managed by NNSA's Office of International Regimes and Agreements (NA-243). The workshop agenda presented a main theme or subject for each of the four days:[2]

- Day one: Share information on existing safeguards/nonproliferation educational activities at the national laboratories and universities.
- Day two: Focus on the multidisciplinary nature of safeguards/nonproliferation education and tools and learning objectives necessary to bridge divides between academic disciplines and departments.
- Day three: Discuss specific course curriculum, degree options and the role of University centers in providing undergraduate and graduate training for safeguards/nonproliferation.
- Day four: Tour Los Alamos National Laboratory to survey safeguards technologies and discuss computer-based learning tools.

On the third day of the workshop eleven LANL safeguards interns joined the attendees for a working lunch. This allowed a sharing of perspectives between faculty and students on ways to make safeguards/nonproliferation education more effective and exciting. Finally, on day four we visited Los Alamos National laboratory for brief tours of safeguards facilities and technology demonstrations.

[1] A list of workshop attendees and their contact information is included in Appendix A.

[2] The workshop agenda is included as Appendix B.

This workshop report is intended to convey the main points and suggested action items that emerged throughout the proceedings. These workshop results are the product of interaction between an exceptionally strong group of university faculty, students and laboratory specialists. We are grateful to the support from NA-243 that allowed us to gather together and are confident that many of the ideas noted below can lead to actions that benefit the NGSI community and strengthen educational opportunities for students in this vital field.

Lessons from NGSI and University Classes Related to Safeguards

While providing background on the NGSI, Ed Wonder from NA-243 stressed the continuing need for educational activities to address a shortfall in nuclear safeguards/nonproliferation professionals at the national and international levels. There was broad agreement among the participants on this point, although many also expressed the need to better understand the dimensions of the shortfall by conducting carefully structured workforces studies in the near term. For example, it was noted that the International Atomic Energy Agency (IAEA) expects a modest growth in the need for safeguards inspectors but a sharp increase in the need for more professionals who can analyze nuclear safeguards and proliferation relevant information. Because the IAEA is just one of the organizations that needs safeguards professionals this illustrates the need for more detailed workforce studies. More accurate information provided to universities on the needs of the safeguards community and the specific skills required by that community will allow them to create more effective curriculum.

A second major point raised by faculty participants was that university R&D is of fundamental importance to developing and sustaining a strong university capability to educate the next generation of U.S. nonproliferation and safeguards experts. This also became a workshop keynote. Research grants cover the majority of the tuition and expenses for graduate students in the natural sciences and university faculty and administration would be more enthusiastic about offering new courses and degree options in safeguards/nonproliferation if they had more confidence that research money will be available in those fields to attract students. NGSI presently does not involve university R&D support, but the NA-22 and NE university R&D programs do. Increased coordination with these organizations on their university R&D programs to ensure a safeguards focus to some investment would be beneficial.

The survey of NGSI summer safeguards classes at the national laboratories and the existing university courses raised several points regarding approaches to subject materials, supporting students throughout their university education and professional training, and meeting future workforce needs. Participants highlighted the complexities of this subject material as an educational challenge. The technical, historical, political, legal and theoretical complexities of the field highlight the need for multidisciplinary courses early in the educational program and for some preliminary exposure to international relations theory and the evolution of nuclear technology in the context of the Second World War and the Cold War. It is also vital for students to have basic understanding of deterrence theory and the dynamic new security environment that has emerged following the Cold War.

The complexities of the subject matter raised another point that became a central theme of the workshop: Nuclear safeguards/nonproliferation training is by nature a multi- or trans-disciplinary undertaking. This highlighted the importance of designing into course curriculum opportunities for students to cross disciplinary boundaries. Many faculty attendees at the workshop demonstrated that their course and degree offerings already reflected a multidisciplinary approach but agree that more could be done to prepare students to cross the policy-technology divide in the field of nuclear safeguards/nonproliferation. These issues are discussed in more detail in a subsequent section on multidisciplinary approaches.

Some final observations from the review of existing and planned safeguards/nonproliferation classes and programs in the university setting included the need to fit them into existing degree programs, faculty teaching responsibilities and research focus areas. Gaining the necessary administrative approvals for new course offerings and degree programs requires time and effort. University administration officials are reluctant to grant approvals if the requests are judged to weaken faculty support for students of existing course and degree offerings. Still, such proposals for new course offerings, certificate, and degree programs can be successful as indicated by their creation at several participating universities.[3] Well-documented workforce studies describing future employer needs help faculty make the case for these offerings as well as strong student interest and the availability of research funding.

The safeguards/nonproliferation training activities at the national laboratories are less constrained and offer a variety of experiences for technical and non-technical students. The five laboratory programs had slightly different elements and emphasis on the policy versus technical aspects of the field. All of them featured lectures by safeguards specialists covering a broad range of technical and policy topics. Most also had some technical demonstrations or real laboratory component, facility tours and some problem set or exercise for students to address. Generally speaking the programs at Brookhaven national lab and the joint Livermore lab-Monterey Institute course are more policy oriented while the programs at Los Alamos, Oak Ridge and Pacific Northwest national labs are more technically oriented.[4]

There was strong agreement that more interaction between the university and laboratory training programs and their instructors will provide even richer and more diverse opportunities for students and post-docs. Sharing presentation and reference materials, co-designing and sharing laboratory and classroom exercises and assignments and implementing a reciprocal visiting lecturer schedule are all simple ways to increase course integration. The rotation of faculty and students through the university and lab settings is another beneficial approach to explore, despite greater logistic and administrative requirements.

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[3] See the summary of safeguards/nonproliferation courses and degree programs in Appendix C.

[4] The workshop briefings on lab and university courses are available at http://www.lanl.gov/orgs/ndo/index.shtml. Click on the “learn more” phrase in the blue box.

Suggested NA-24 Actions:

- Produce a publicly releasable version of the on-going NGSI detailed workforce needs study for the wider nuclear safeguards/nonproliferation community as a means to address concerns of university partners as to the projected need for nonproliferation/safeguards experts and justification for new courses related to these areas
- Increase safeguards/nonproliferation research at the universities and to adequately fund that research. Distribute a list of government and private research opportunities. Coordinate with NA-22 and NE regarding solicitations for university R&D in safeguards technologies.
- Provide nuclear safeguards/nonproliferation courses materials generated at the national labs to universities for inclusion into existing degree programs, and support development of new nonproliferation/safeguards courses. Target university programs that offer some leveraging opportunities through distance learning, and also university networks that allow course sharing for credit.
- Increase integration of lab and university course by sharing presentation and reference materials, co-designing and sharing laboratory and classroom exercises and assignments, and implement a reciprocal visiting lecturer schedule.

Materials and Learning Tools for Multidisciplinary Safeguards/Nonproliferation Education

Consistent with their strong agreement that nuclear safeguards/nonproliferation is by nature a multidisciplinary and international field of study, workshop participants spent significant time discussing specific ways to reflect this in their course programs. The difficulty of this challenge should not be underestimated. Neither should the benefits be overlooked of being confident in both the technical and policy aspects of nuclear safeguards/nonproliferation for those students who are drawn to this field.

Ideally, nuclear safeguards/ nonproliferation professionals should have command of the body of national and international laws, regulations, conventions, treaties, guidelines and procedures that seek to safely and securely manage civil nuclear activities and prevent the spread of nuclear weapons. Nuclear safeguards experts must also understand the fundamental methods for measuring, controlling and accounting for nuclear materials, verifying activities at declared nuclear sites and searching for undeclared activities and illicit procurement networks. A core of technologies and methodologies to accomplish these tasks include destructive and nondestructive assay of nuclear materials, containment and surveillance, unattended and remote monitoring, environmental sampling, nuclear forensics and information analysis. Furthermore, nuclear safeguards experts need knowledge of the civilian nuclear fuel cycle and the basics of the nuclear weapons development process. The ability to grasp how the

nuclear fuel cycle can be misused to support a weapons program, combined with knowledge of the policy and detection methodologies, give an individual the skills to design and evaluate effective nuclear security and safeguards systems and to identify policy and technology gaps for future research and development. Finally, it is critical that students in this area also become familiar with the range of potential threats that must be considered for safeguards and physical protection, as well as potential events that could initiate threats and must be considered for the safety and reliability of safeguards systems.[5]

This large body of knowledge and skill is difficult to master through academic training alone. There was broad agreement that the minimum of a master's degree with some combination of social and natural sciences would be required to familiarize students with a majority of this technical, historical and political knowledge. Workshop participants acknowledged the need for this skill set (although some questioned the scale of the need) and offered creative and focused suggestions for meeting it. The strength of the diversity of workshop participants was evident in the range of proposed actions.

The suggested activities included the need for research papers with technical content, team projects with lab content, debates, simulation exercises, technology demonstrations and chances for students to engage with research organizations outside the classroom. For graduate students specializing in nonproliferation, a requirement that one of their thesis committee members be from another academic department was one suggestion. Another was to make assignments that would demonstrate to students the widely contrasting range of opinion on matters related to nuclear safeguards such as the debate over Iraq's nuclear weapons efforts in the period prior to the U.S. Invasion of Iraq in 2003.

It was also mentioned that student tours of nuclear power plants, storage facilities, fuel fabrication plants, and experimental facilities can broaden opportunities for students to see the range of applications for their safeguards/nonproliferation training. Ideally, universities could establish relationships with key nuclear facilities which do not exist on their campuses such as research reactors, unique facilities such as the Cooperative Monitoring Center at Sandia National Laboratory, or the Department of Energy National Training Center in Albuquerque. One innovative idea was to create mobile safeguards technology demonstrations, partly funded by industry sponsors, to allow exhibitions to travel to many universities annually. This would provide a richer learning experience compared to reading about safeguards instruments or looking at simulated data on-screen.

Other features of the multidisciplinary approach were to support cross-departmental research, require some number of extra-departmental courses, take maximum advantage of student safeguards activities at the national laboratories, and encourage student involvement with professional associations such as the Institute for Nuclear Materials Management (INMM). Providing opportunities to interact with notable safeguards/nonproliferation experts is also a means of exposing students to the multidisciplinary nature of this subject. Most workshop participants agreed that the key factors

[5] The authors are grateful to Per Peterson for offering this point after his review of the workshop report.

enabling such multidisciplinary innovation in training opportunities are the presence of a faculty champion, student interest, sustained safeguards/nonproliferation research funds and the ability to place graduating students in desirable jobs.

The workshop made clear that a small number of university programs across the country already proceed from a multidisciplinary approach to safeguards/nonproliferation training. Workshop participants heard descriptions of the minors and certificate degree programs that often had requirements for combining credits from physical and social science departments. Participants were encouraged by the many suggestions for increasing multidisciplinary content made above and commented that they would pursue some activities that they were not already integrating into their teaching. Of course, the point was made that financial resources are needed for many of the proposed activities.

One specific proposal supported by many in the group was to create a national or international association of educators in the field of nuclear safeguards/nonproliferation. This association could serve several important functions to increase the quality and availability safeguards education. It could facilitate the sharing and joint development of course curricula and learning tools. It could gather and distribute information on relevant research grant opportunities and perform outreach activities to attract students to the field. It could also support university-laboratory collaborations, lobby for cross-departmental and cross university course credit approval for safeguards related degree or certificate programs and sponsor multidisciplinary faculty seminars. In general such an association could help build university programs that define and model the multidisciplinary approach to nuclear safeguards education. It could also promote and recognize excellence in this field.

Other useful activities that could strengthen the multidisciplinary approach include exchange programs for professors that allowed them to teach for a semester in another university department or at another university. Such a program could be encouraged by an association of educators and implemented at participating universities. It was noted that several major grant-giving organizations such as the National Science Foundation (NSF) and the MacArthur Foundation are encouraging such interaction between social sciences and natural or physical sciences. Individual universities or an association of educators could work with such organizations to develop grant programs focused around specific grand challenges in the field of safeguards/nonproliferation.

On the subject of reference and reading materials it was noted that there were not enough true textbooks with problem sets and solution keys for use in nuclear safeguards classes at the graduate or undergraduate level. Also needed are more reference texts that provide a survey of the various disciplines within the safeguards/nonproliferation field and demonstrate through analytical or lab exercises why they are important. Fortunately, several texts are available or in progress that are suitable for core readings in this field. A brief list of reading and reference sources known to workshop participants is provided in Appendix D.

Suggested Actions for Educators:

- Design master's degree or graduate certificates in safeguards/nonproliferation to include some combination of social and natural sciences courses to familiarize students with a majority of the technical, historical and political knowledge required to become a safeguards expert.
- Assign research papers with technical content, team projects with lab content, debates, technology demonstrations and requirements that students engage with research organizations outside the classroom.
- Require that graduate students have on their thesis committee at least one member from another academic department or university.
- Demonstrate to students the widely contrasting range of opinion on matters related to nuclear safeguards.
- Arrange student tours of nuclear power plants, storage facilities, fuel fabrication plants, and experimental facilities. This could be facilitated by support from NA-24.
- Establish relationships with key nuclear facilities which do not exist on campus such as research reactors, the Cooperative Monitoring Center at Sandia National Laboratory, or the Department of Energy National Training Center in Albuquerque.
- Create mobile safeguards technology demonstrations with industry sponsors. This could be supported by NA-24.
- Support cross-departmental research.
- Encourage student involvement with professional associations such as the Institute for Nuclear Materials Management (INMM).
- Provide students opportunities to interact with leading safeguards/nonproliferation experts.
- Create a national or international association of educators in the field of nuclear safeguards/nonproliferation.
- Develop more textbooks and reference sources with problem sets and solution keys for use in nuclear safeguards classes at the graduate or undergraduate level. This is a role for scholars outside the university as well.

Course Curriculum, Degree Options and the Role of University Centers

The suggestion that new, focused degree programs were needed in the area of nuclear safeguards/nonproliferation raised concern among some workshop participants that such a focus was so

specialized that there will not be enough future jobs to absorb all graduating students and post-docs. Several faculty members cited this concern as a hurdle they face in winning support from administration officials for new courses and degree/certificate programs in this area. This reinforced the need for authoritative workforce studies that confirm a long-term need for safeguards professionals. It also led to a common, but not unanimous view that it may be more in the interests of students and universities to offer safeguards majors, modules, or certificates within traditional degree programs such as physics or nuclear engineering rather than creating a specialized safeguards degree program. Several of the university faculty expressed concerns that a traditional nuclear engineering degree as a foundation maybe more desirable to nuclear industry employers as compared to a degree program that is unfamiliar to them or appears too narrow.

This discussion reflected in part the current reality that nuclear engineering graduates are receiving multiple job offers from the industry, and that, except for those students who decide early on to pursue nonproliferation careers, injecting new nonproliferation course requirements into established nuclear engineering curricula would have little positive impact on the career prospects of those students not going on in nonproliferation careers.

Non-faculty and government workshop participants for the most part were less concerned about workforce issues. This is partly based on a perception of sustained or growing need for safeguards/nonproliferation specialists across a broad range of employers including the national laboratories, various U.S. government agencies, the International Atomic Energy Agency (IAEA), and the global nuclear industry. They highlighted the advantage that a degree or certificate program in nuclear safeguards/nonproliferation might provide to candidates approaching these employers in a competitive job market.

Perhaps one useful way to approach the safeguards/nonproliferation educational challenge is to visualize it in terms of pyramid. The base is modules in existing courses at the undergraduate level; the middle part is a graduate course on nonproliferation and safeguards that covers multidisciplinary terrain and possibly one or two more specialized and narrower courses that build on the first one; and the top a very small number of in depth curricula culminating in a graduate certificate, and offered by a small handful of schools.[6]

There was broad agreement that these differing perspectives should not discourage innovation in university programs to attract the best students into the safeguards/nonproliferation field. Students attracted to this field are often motivated by altruism. They want to make a positive difference in their world and they are inspired by the public service aspects of reducing global dangers posed by nuclear weapons and materials. This was reinforced by roundtable discussions between the workshop participants and LANL safeguards students.

[6] The authors thank Ed Wonder, NA-243 for suggesting this perspective after his participation in the workshop.

It is in the national interest to encourage this desire towards public service among students and engage them as soon as possible with the grand challenges of safeguards/nonproliferation. This will help recruit highly skilled and motivated professionals, many of whom are likely to take positions supporting various U.S. and global security interests. Some grand challenges mentioned by workshop participants and students include:

- Can the use of nuclear energy be expanded while the risk of nuclear proliferation is lowered?
- Can IAEA safeguards meet quantity and timeliness goals for materials accountancy for large throughput nuclear facilities?
- Can undeclared nuclear activities be detected and countered?
- What are the political, technical and institutional requirements for the elimination of nuclear weapons?
- How can we decrease illicit trafficking in nuclear materials and technology?

If students grasp these challenges during their training, and are given opportunities to work on solutions to them in both in the university and external settings, then the field of nuclear safeguards/nonproliferation will have a better chance of successfully competing with academia and industry for their labor in a tight market.

In addition to introduction to grand challenges, it is vital that students have an internship or external work opportunity to expose them to how these challenges are addressed in real-world setting and provide some degree of on-the-job training. This is more important at the graduate level but several students expressed the desire to have such opportunities as early as possible in their training. The question was raised whether a summer or semester-long internship should be a requirement for graduate level training in safeguards/nonproliferation. This drew mixed reactions from workshop participants. Those in favor of this requirement strongly endorsed its value and some educators in the social sciences said it was already part of their graduate requirements. On the other hand, faculty from nuclear engineering departments worried that a 3-6 month internship requirement would be too restrictive on students that need to be in residence at their universities for research purposes. It could also significantly delay the completion of a degree program.

A possible solution to these concerns would be for students to enroll in internships in between degree programs, either immediately following completion of their undergraduate degree or master's degree. This would allow more flexibility on the length on internships and not hinder swift progress towards a degree. From the perspective of national laboratory staff who offer internships utilizing students for sponsor-funded research and deliverables this approach has the benefit of allowing the interns to spend a longer period of time at the laboratory. This would likely be viewed as a benefit by other internship opportunities that offer on-the-job experiences due to the fact that the longer an employee is immersed in a task the more value they can bring to a team.

Another valuable element of a safeguards/nonproliferation curriculum is to involve students with exercises and scenarios that simulate real-world problems and require complex analysis to resolve with proposed solutions or actions. Such exercise help students assimilate the knowledge they have gained in

different classes. Exercises that were used during the national lab internships included the creation of hypothetical IAEA State Evaluation Reports for safeguards conclusions, open source analysis approaches for assessing undeclared nuclear activities or facilities and mock debates within international organizations where students would have to argue the case for various state actions or decisions. There was agreement that these exercises can be integrated with other off-site partners and universities and that it would benefit the entire safeguards/nonproliferation community if such exercises could be documented and shared via an information portal.

Suggested Actions for Educators:

- Inform students that degree or certificate programs in nuclear safeguards/nonproliferation can provide advantages to candidates who desire to enter this specialized field when approaching employers in a competitive job market.
- Encourage the desire towards public service among students and engage them as soon as possible with the grand challenges of safeguards/nonproliferation.
- Provide students with an internship or external work opportunity to expose them to how nuclear safeguards challenges are addressed in real-world setting and provide some degree of on-the-job training.
- Involve students with exercises and scenarios that simulate real-world problems and require complex analysis to resolve. Involve outside organizations in these exercises.
- Share the results and solution keys for exercises with the wider safeguards educational community.

Safeguards Technologies and Computer-based Learning Tools

On the final day of the workshop, participants visited Los Alamos National Lab Nuclear Safeguards facilities and received tours and technology demonstrations. These activities are a strong learning experience for faculty and students alike and participants agreed that they should be a part of safeguards training. Participants viewed several customized safeguards instruments for measuring nuclear materials in reactors, spent fuel ponds, dry storage areas and reprocessing operations. In addition, operation of a vehicle portal monitor for detecting nuclear materials was demonstrated as well as software for creating virtual models of nuclear facilities and visualizing interactions between safeguards measurement systems and target nuclear materials.

The virtual reality software demonstration in particular generated a lot of interest as possible classroom teaching tools. Not only can the program create accurate scale photorealistic nuclear facilities, it can simulate the performance and output of safeguards instrumentation such as cameras, detectors, gates, locks, tags and seals. In this way it can bring the nuclear facility into the classroom for orientation and design exercises rather than having to send students to facilities with all of the restricted access, time

and cost burdens. Los Alamos staff and some faculty participants plan to further explore using this technology in the classroom.

Workshop participants were also given a demonstration of using open-source satellite imagery and associated tools to analyze nuclear facilities and undeclared activities. This technology and its application to nonproliferation safeguards issues made a strong impression with faculty, several of whom remarked that they could use it in their training programs. This is an area in which the laboratories can provide more technical assistance to university courses and perhaps collaborate on using these tools for classroom study, research projects and exercises.

The other computer-based learning resource that was discussed often throughout the workshop was the need for a multi-function web-based information portal to support safeguards/nonproliferation education. This site should have the ability to:

- Distribute all NGSI internship and safeguards lectures
- Maintain an accessible, extensive on-line bibliography and reference library of printed safeguards materials
- Distribute distance learning courses on safeguards/nonproliferation and provide links to other universities distance learning resources
- Maintain links to videos of lectures, labs, seminars and films on nuclear safeguards/nonproliferation
- Link to the Nuke Wiki site
- Share exercises and simulations
- Maintain an updated bulletin board with descriptions of academic and other nonproliferation training programs, a list of potential grants and job and internship opportunities
- Provide links to professional organizations such as INMM and university career centers

Workshop participants discussed potential providers of such a portal and tried to outline the functions that would have significant maintenance requirements. The conclusion was that this would be a substantial but vital service that could help define, strengthen and sustain the safeguards educational effort. Because of cost and information sensitivity issues it was generally accepted that a national laboratory was not the best provider for such a service. A university consortium or partnership between universities and private or non-governmental organizations could offer more effective support for an actively maintained, multi-feature web portal.

There was some discussion regarding the challenges and advantages of creating a university center to host and promote nuclear safeguards/nonproliferation training and research. Reactions to this idea were mixed. Several participants noted that the effort and resources required for such an effort dictated that only large, well established (and funded) university departments could consider creating a center. Others believed that this could only be possible as collaboration between several university departments and outside organizations and that a large grant or Congressional earmark would be required. They also questioned how many such centers could be sustained in the United States and what the effects of competition for funding might be.

On the positive side, the existence of a university center can be a strong selling point for grant proposals, an attractive atmosphere for leading scholars in the field and an administrative structure that can promote academic activities and seek external resources. Several universities attending the workshop have centers devoted to issues of nuclear security, nonproliferation and safeguards and find them very beneficial to their academic training program. It was noted that the subject of nuclear safeguards was probably too narrow to serve as the basis of a sustainable and impactful university research center, but it could be an important program within a broader academic agenda. Perhaps the most important role that university centers can play is to increase both public and student interest in an area of policy and science, and to offer high quality publications, seminars and events. University departments that do not have a dedicated center can benefit from establishing connections with one that promotes similar interests.

Suggested Actions for NA-24 and Educators:

- Explore the use of virtual reality software technology for use in university training for nuclear safeguards/nonproliferation.
- Create a multi-function web-based information portal to support safeguards/nonproliferation education.
- Consider the creation of university centers devoted to research and teaching in nuclear nonproliferation and safeguards. Where this appears infeasible or unnecessary consider establishing connections to a leading academic center for teaching and research collaborations.
- Follow-up on university interest in open-source imagery analysis for nonproliferation/safeguards learning and research. Support collaborations between universities and labs in this area.

Conclusions

The Workshop on University Collaborations for Safeguards/Nonproliferation Education was a success. Valuable perspectives and many specific recommendations were shared that can strengthen our collective safeguards education effort. One significant benefit of the event was its contribution to community building. It was one of the first opportunities for faculty, students, laboratory scientists and government representatives to gather and discuss their common efforts to improve nuclear safeguards/nonproliferation education. It was recommended that such events continue. What is most important now is that this community works together to take concrete steps to implement the suggested actions. This workshop report is intended to be a reminder and reference guide for action. It is hoped that other reports on the subject will follow from our expanding community and that they will evolve into useful guidelines for future accomplishment.

Appendix – A

University Collaborations for Safeguards Education
LANL/TAMU NGSI Human Capital Development Workshop Agenda
Los Alamos National Laboratory

Day 1 – Monday August 10, 2009

8:00- 8:30 am	Registration	
8:30- 9:00 am	Welcome and Introductions	Jim Doyle William Charlton
9:00- 10:00 am	Discussion of Workshop Objectives: ▪ NGSI Overview, HCD Project Goals (15 min) ▪ Faculty Goals and Resource Needs (45 min)	 ▪ Ed Wonder ▪ William Charlton Doug Shaw
10:00- 10:15 am	Break	
10:15am- 12:00pm	Faculty Perspectives: Challenges and Approaches for Teaching Safeguards/Nonproliferation ▪ Perspectives from Law, Politics, and International Affairs (50 min) ▪ Perspectives from Science and Engineering (50 min)	 ▪ Joe Pilat Michael Rosenthal Jim Doyle ▪ Jason Hayward Gary Cerefice
12:00- 1:30pm	Lunch (on your own)	
1:30- 3:00pm	Descriptions of Existing Courses ▪ Graduate Level (45 min) ▪ Undergraduate Level (45 min)	 ▪ Jim Finucane Sara Pozzi ▪ Joe Pilat Kathleen Trauth
3:00-3:15pm	Break	
3:15- 4:45pm	Brief Descriptions of the NGSI HCD Projects ▪ LANL/TAMU Summer Course (15 min) ▪ MIIS/LLNL Summer Course (15 min) ▪ LLNL Lecture Series and Exercise (15 min) ▪ ORNL NDA Course and NGSI Workshop (15 min)	 ▪ Jim Doyle ▪ Elena Sokova ▪ Mona Dreicer ▪ Bernie Kirk

	▪ BNL Summer Course (15 min) ▪ PNNL Activities (15 min)	▪ Michael Rosenthal ▪ Carrie Mathews
4:45- 5:00pm	Summary of Day 1	Jim Doyle

Day 2 – Tuesday August 11, 2009

9:00- 10:30am	Nuclear Safeguards as Multidisciplinary ▪ Overview of Safeguards History and Mission (30 min) ▪ Technical Fundamentals of Safeguards (60 min)	▪ Jim Tape ▪ Steve Tobin (30 min) Brian Boyer (30 min)
10:30-10:45am	Break	
10:45am- 12:30pm	▪ Safeguards Learning Objectives and Reference Resources ▪ Lecture-based, Lab-based, and Distance Learning Tools for Safeguards Education	▪ Tom Shea ▪ Brian Boyer William Charlton Fred Wehling Jack Brenizer
12:30- 2:00pm	Lunch (on your own)	
2:00- 3:30pm	Panel on Development of Curricula Bridging Natural and Social Science Departments	Doug Shaw Jim Doyle
3:30- 3:45pm	Break	
3:45- 4:45 pm	Roundtable on Multidisciplinary Approaches to Safeguards Education	
4:45- 5:00pm	Summary of Day 2	Jim Doyle

Day 3 – Wednesday August 12, 2009

9:00- 10:30am	Presentation of Reading and Exercise Material	Mike Rosenthal Fred Wehling
10:30- 10:45am	Break	
10:45am- 12:00pm	Break into Small Groups to Discuss Course Materials, Assignments, and Exercises	
12:00- 1:30pm	Working Lunch: LANL Student Discussion	

1:30- 3:00pm	Panel on Learning Objectives for Graduate vs. Undergraduate Level Courses and For Introductory-advanced Modules	Glenn E. Sjoden Sudarshan Loyalkas
3:00- 3:15pm	Break	
3:15- 4:30pm	Panel Discussion on Design of Degree Options, Concentrations, or Certificate Programs in Nuclear Safeguards and the Role of University Centers ▪ What is needed to sustain these? ▪ What should common elements of a certificate program be?	William Charlton Elena Sokova Mark Pierson
4:30- 5:00pm	▪ Provide Faculty with Contact Information of Lab and Subject Matter Experts Available to Provide Guest Lectures ▪ Summary of Day 3	Jim Doyle
6:00- 9:00pm	Banquet ****Zuni North Room****	

Day 4 – Thursday August 13, 2009

Tours and Technical Demonstrations

LANL Facilities, Los Alamos

7:45am	Shuttle leaves from Inn at Loretto to LANL Facilities	
9:00- 10:00am	Building 27 Schoolhouse Tour	Johnna Marlow
10:00- 11:00am	UNARM Tour	Mike Browne
11:00am- 12:00pm	NDA Lab Tour	Steve Tobin LANL Students
12:00- 1:30pm	Lunch (Otowi Cafeteria)	
1:30- 3:00pm	SLD Demonstration	Jim West Eric Rauch
3:00- 4:00pm	Virtual Reality Tour	Birchard Hayes Kelly Michel
4:00- 5:00pm	Tabletop Open Source Demonstration	Rick Wallace Frank Pabian
5:00pm	Shuttle from LANL to Inn at Loretto	

Appendix - B

Next Generation Safeguards Initiative (NGSI)
Nuclear Safeguards University Curriculum Development Workshop
Santa Fe and Los Alamos, NM., August 2009

Attendees List

Name	*University*	*Contact Information*
Boyer, Brian	Los Alamos National Laboratory Safeguards Science and Technology	Los Alamos National Laboratory MS E541 Los Alamos, NM 87545 bboyer@lanl.gov (505) 606-2368
Brasure, L. Wayne	Stockpile Sustainment Manager NNSA NA-122.2	Stockpile Sustainment Manager NNSA NA-122.2 wbrasure@doeal.gov (505) 845.6944
Brenizer, Jack	Pennsylvania State University Mechanical and Nuclear Engineering	Mechanical and Nuclear Engineering 138 Reber Building Pennsylvania State University University Park, PA 16802 brenizer@engr.psu.edu (814) 863-6384
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Appendix – C

University Courses and Degree Programs in Nuclear Safeguards/Nonproliferation

University Department	Undergraduate Nonproliferation Class(es) Offered	Graduate Nonproliferation Class(es) Offered	Degree or Certification Awarded?
Georgia Institute of Technology Center for International Strategy, Technology, and Policy Sam Nunn School of International Affairs	* Problem of Proliferation		
George Washington The Elliot School of International Affairs		*Nuclear Weapons *Arms Control and International Law, *Nuclear Proliferation: Political Dynamics and Technical Constraints *Negotiating Nuclear Nonproliferation *Weapons of Mass Destruction and Non-State Actors	
Georgetown University Health Physics		*Radiation Science *Health Physics *Environmental Health Physics *Introduction to Nuclear Nonproliferation *Radiation Detection *Nuclear Weapons Detection *Nuclear Weapons Production Cycle *Indicators of Nuclear Proliferation	M.S. in Health Physics, focus on Nuclear Nonproliferation
Georgetown University Walsh School of Foreign Service	*Nuclear Technology and Security * Military Security in World Politics * The U.S., India, Pakistan, and Afghanistan		
Georgetown Law School		*Nuclear Non-Proliferation Law & Policy: Preventing Nuclear Terrorism	

MIT Nuclear Engineering		*Managing Nuclear Technology	
Monterey Institute of International Studies		*Nuclear Weapons Technology *Chemical Weapons Technology *Biological Weapons Technology *Missile and Missile Defenses *Chinese Nonproliferation and Security *Nuclear Proliferation Trends and Trigger Events *Nonproliferation in the NIS *Security and Nonproliferation Issues in the Middle East *Terrorism and Weapons of Mass Destruction *Weapons of Mass Destruction Proliferation in South Asia *South Asia And WMD *Chemical and Biological Weapons and Arms Control *Cooperative Threat Reduction Process in FSU *Security & Arms Control in Northeast Asia *Export Controls *Arms Control Simulation *Nonproliferation Organizations and Regimes *History of U.S. Nuclear Weapons *Iran's Nuclear Weapons Program *Emerging WMD Supply Networks *Comparative National Security Policy *International Space Policy *Technology & International Security *Terrorism in South Asia *Emerging Issues in International Public Health *Contemporary Issues in Nonproliferation (Taught in either Chinese, Japanese, or Russian)	Masters of Arts in International Policy Studies, Certificate in Nonproliferation Studies
Stanford University Center for International		*Nuclear Weapons, Terrorism, and Energy *History of Nuclear Weapons	

Security and Cooperation		*The Science, Technology, and Politics of Missile Defense *Technology and National Security *Weapons and Nuclear Proliferation	
Texas A&M University Nuclear Security Science & Policy Institute	*Nuclear Nonproliferation	*Nonproliferation and Arms Control *Nuclear Fuel Cycles and Safeguards Systems *Radiation Detection and Nuclear Materials *Critical Analysis of Nuclear Security Data * WMD Detection, Response, and Recovery *Nuclear Reactor Theory *Nuclear Radiation Shielding *Nuclear Reactor Analysis and Experimentation	M.S. in Nuclear Engineering (Nuclear Nonproliferation Specialization)
University of California Berkeley	*Analytical Methods for Nonproliferation		
University of Georgia	*Introduction to Arms Control, Disarmament and Nonproliferation		
University of Illinois, Urbana-Champaign Program in Arms Control, Disarmament, and International Security	*Nuclear Weapons and Arm Control		
University of Illinois, Urbana-Champaign Nuclear, Plasma, and Radiological Engineering	* Military and Civil Uses of Nuclear Energy	* Military and Civil Uses of Nuclear Energy	
University of Michigan Department of Nuclear	Nuclear Instrumentation Laboratory Nuclear Engineering Materials Application of Radiation	Interaction of Radiation and Matter Nuclear Measurements Laboratory Advanced Radiation Measurements and Imaging	

Engineering & Radiological Sciences	Nuclear Reactor Theory I Nuclear Power Reactors Reactor Safety Analysis Engineering Principles of Radiation Imaging Radiological Health Engineering Fundamentals Detection Techniques for Nuclear Nonproliferation Nuclear Safeguards	Radiation Effects in Nuclear Materials Nuclear Fuels Nuclear Waste Management Nuclear Reactor Theory II Nuclear Reactor Kinetics Radiation Shielding Nuclear Core Design and Analysis I Nuclear Core Design and Analysis II Computation Projects in Radiation Imaging Applied Radiation Dose Assessment Transportation of Radioactive Materials Applied Radiological Measurements Internal Radiation Dose Assessment Radiation Safety and Medical Physics Practicum Detection Techniques for Nuclear Nonproliferation Nuclear Safeguards	
University of Missouri Nuclear Science and Engineering		*Science and Technology of Terrorism & Counter-Terrorism *Non-Proliferation Issues for Weapons of Mass Destruction *Sect. 2 Terrorism & Counter Terrorism *Nuclear Safeguards Science and Technology *Radiation Safety *Nuclear Radiation Detection *Interaction of Radiation with Matter *Nuclear Fuel Cycle * Nuclear Reactor Theory * Advanced Radiochemistry * Nuclear Physics * Neutron Transport Theory * Advanced Fusion Theory * Interaction of Radiation with Matter * Nuclear Reactor Laboratory * Introduction to Nuclear Reactor Engineering	Graduate certificate in Nuclear Engineering and Safeguards

		* Introductory Radiation Biology	
University of New Mexico Department of Chemical and Nuclear Engineering	*Introduction to Nuclear Nonproliferation Analysis	*Introduction to Nuclear Nonproliferation Analysis	No
University of North Carolina	*Nuclear Nonproliferation Policy		
University of Washington Institute for Global and Regional Security Studies	*International Law and Arms Control *Weapons of Mass Destruction * Arms Control Simulation * Perspectives on the Nuclear Fuel Cycle and Nonproliferation * The Pacific Northwest Colloquium on International Security		
Virginia Tech Mechanical Engineering Department	* Nuclear Fuel Cycle	* Nuclear Fuel Cycle	Looking to start graduate certificate in nonproliferation

Universities in the process of adding or considering adding Nonproliferation courses/certificate programs:

Oregon State University, Department of Nuclear Engineering and Radiation Health Physics
Pennsylvania State University, Department of Mechanical and Nuclear Engineering
Rensselaer Polytechnic Institute, Department of Mechanical, Aerospace and Nuclear Engineering
University of Nevada, Las Vegas, Harry Reid Center for Environmental Studies
University of Tennessee, Nuclear Engineering, Baker Center for Public Policy and Political Science
University of Wisconsin-Madison, Department of Engineering Physics

Appendix - D

A Partial List of Safeguards/Nonproliferation Reference/Research Materials

Matt Bunn and Anthony Weir, *Securing the Bomb,* Annual Volume available from the Nuclear Threat Initiative http://www.nti.org/e_research/cnwm/overview/cnwm_home.asp

James E. Doyle et al., *Nuclear Safeguards, Security and Nonproliferation,* Elsevier Science and Technology, June 2008
http://www.elsevier.com/wps/find/bookdescription.cws_home/714662/description#

Dave Hafemeister, *Physics of Societal Issues,* Springer 2007

Thomas C. Reed and Danny B. Stillman, *The Nuclear Express* , Zenith Press, 2009

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D.R. Joy, Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C.

MCA-101DC, Introduction to Materials Control and Accountability, U.S. Department of Energy National Training Center, Safeguards and Security Central Training Academy, April 2002.

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Bruno Pellaud. "The strengthened safeguards System: Objectives, Challenges and Expectations", in Erwin Hackel and Gotthard Stein, editors. Tightening the Reins: Toward a strengthened International Nuclear Safeguards System (Germany: Springer, 2000), pp. 89-98.

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Richard Hooper. "The changing Nature of Safeguards" IAEA Bulletin 45/1 (June 2003), pp. 7-11. Available at http://www.iaea.org/Publications/Magazines/Bulletin/Bull451/article2.pdf

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Limits and effectiveness of safeguards

David Fischer and Paul Szasz. Edited by Josef Goldblat. Safeguarding the Atom: A critical appraisal. (USA: Taylor & Francis, 1985), chapter 5: "The risk of secret nuclear plans", pp. 35-40; chapter 6: "Limits to the present approach", pp. 41-45; chapter 7: "Problems with safeguards methods", pp. 47-58.

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